RAPID RELIEF: A PREFABRICATED RESPONSE

An Undergraduate Research Scholars Thesis

by

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TABLE OF CONTENTS

Page

ABSTRACT

Rapid Relief: Architectural Palimpsest. (December 2012)
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As illustrated by the aftermath of disasters such as Hurricanes Katrina, Ike and Sandy, the disaster response phases do not entail an effective or standard procedure for rebuilding damaged and destroyed residences. I propose the implementation of prefabricated construction techniques with the utilization of Building Information Modeling (BIM) technology into the rebuild phase that would proceed throughout the entire duration of disaster recovery, starting with the immediate respondents. My research provides a variation of sample projects ranging from previous buildings erected in response to a hurricane to prefabricated projects that are able to be assembled rather than constructed. With these projects, I am able to analyze their construction methods in order to determine an adequate proposal for disaster reconstruction. My belief is that a standardized procedure would allow for an expedited response time, a structured addressing of the needs of the affected residents, and a sufficient start to the reconstruction of the victim's futures.

CHAPTER I

INTRODUCTION

Even before the occurrence of a disaster, either technological (human-caused) or natural (environmentally-caused), numerous procedures are implemented under specific jurisdiction in order to either prevent or merely mitigate the results of the event. And of course, if the disaster proceeds to occur despite the attempts to either prevent or merely mitigate the results, numerous procedures are implemented under specific jurisdiction in response to the event. Yet even with the implementation of the numerous procedures, there is no mandated assessment to the demand of reconstruction. Instead, property damage is evaluated by insurance agencies and the rebuild phase is placed on hold until all costs are accounted for and calculated. In extreme cases of which the local or state government can no longer meet the imposed demands of the people, the federal government will provide assistance through generous monetary contributions. Once the financial means are accounted for, contractors begin the reconstruction of the victim's lives.

Fortunately, other organizations are usually formed in order to assist in the recovery phase of the affected areas. In December 2006, more than a year since the devastation of Hurricane Katrina, actor and film producer Brad Pitt founded Make It Right in New Orleans. Their plan was to reconstruct 150 houses in the Lower 9th Ward which "the national media declared an unsalvageable wasteland" (Pitt, 2009). Yet despite the doubts, after seven years the program successfully completed 86 LEED Platinum certified houses resulting in the housing of over 350 people. But even with all of the generous contributions and numerous organizations

collaborating in order to assist in the rebuild of New Orleans, the task to this day remains incomplete. This, to me, provokes a concern which provides room for adjustment.

Since there is not a specified line of action taken in order to assist in the immediate reconstruction of areas that have suffered property damage due to a disastrous occurrence, I propose a systematic procedure to be conducted throughout the entire process of disaster relief. In this study, I focus strictly on coastal project in order to aid in hurricane disaster relief. My intention is to provide an adequate possible solution for the reconstruction phase of coastal disasters. With my viable final model, I can then adjust specific variables in means of adapting my procedure to other natural, non-coastal, disasters. Though most emergency management programs cover both technological and natural disasters, my research will be strictly focused on the response and recovery following natural disasters with the hopes that my final proposed method and structure will allow for the possibility of evolving in response to human generated catastrophes. I believe that instead of attempting to solve all possible outcomes in accordance to every available variable, one should instead focus on the solution, or the improvement, of a single equation. If steps can be taken in order to increase response and recovery time of a particular disaster and results reveal substantial improvement, the new procedures can then be readdressed in order to adapt to the remaining types of disasters, both technological and natural.

In order to understand the process as well as precedential projects constructed in response to natural coastal disasters, I address not only the structural issues encountered in Louisiana but in Texas as well. Following the destruction of Hurricane Ike, respectively, the city of Galveston underwent substantial property damage similar to, but not exceeding, that of New Orleans'. The reconstruction methods and outcomes produced in the emergency response to these areas are

analyzed in order to determine financial, structural, aesthetic and projected lifespan similarities and differences. With this information, I can determine the procedure that provides the most efficient solution. All of this information will then be taken into consideration as possible solutions for the recovery phase initiated by Hurricane Sandy. With my conclusion, I will provide a reconstruction process as well as a prototypical architectural model designed specifically for the coastal residents of Staten Island. In my study, I plan to determine a model that is not only financially readily available, but is also structurally sounded, self-sustainable and aesthetically pleasing. Considering the fact that my listed mitigating factors consist of a multitude of individual past possible solutions, the traditional reconstruction method previously undergone will not be the proposed resolution. Instead, I also review works outside of disaster relief in order to widen the spectrum of possibilities so as to allow for the best possible conclusion.

Along with the examples of prior recovery structures, I also address several projects with no direct correlation to emergency management. These projects consist of arguments regarding modular structures that can be mass produced as well as prefabricated buildings that can be assembled in mere weeks. These projects are then analyzed in accordance to the disaster relief comparison. Each additional factor, including material and construction time duration, will then be applied as new variables in the process of determining an efficient final architectural model. In order to apply my design into the phases of disaster relief, structural components can gradually be distributed throughout the relief process with each phase contributing to its predecessor. The initial structures addressed on site will consist of immediate shelter with a strong emphasis on residential restoration and/or replacement. My proposed process would allow

for continuous growth while simultaneously minimalizing material waste and time sacrificed for preparation. If each structural fixture was approached with a similar assembling process and each phase was a contribution to the previous, the emergency response process would inherently become more efficient resulting in an accelerated response and recovery time.

BACKGROUND AND POINT OF DEPARTURE

My interest in disaster relief efforts initially began as a response to the fact that a reconstruction phase currently does not exist within the realms of disaster relief efforts. Though it is not the fault of the federal government for the destruction of the homes following a natural disaster, excluding New Orleans after Hurricane Katrina which will be discussed in detail in a latter portion of this paper, there should exist a standard procedure to act as a protocol in order to assist in the rebuilding of a devastated area. Once a standard is established, the procedure can then be altered in order to meet the requirements of not only similar natural disasters, in my case, hurricanes, but technological disasters as well considering the fact that altering a set plan is significantly easier than reproducing a new plan in response to every disastrous occurrence.

In order to obtain a proper understanding of the affects following the destruction of Hurricanes Katrina and Ike along with the criticism generated by the public in regards to FEMA's response efforts, I will review works accordingly. Once a proper understanding is established, I will then review past works regarding dated prefabrication arguments and techniques as well as projects constructed in order to rebuild a community following a natural disaster. In addition to these reviewed works, I will also analyze the process and techniques used within prefabricated projects in order to gain a thorough understanding so as to implement relevant and efficient methods into my concluding model. With this information, I will introduce a rebuild method that utilized

prefabricated construction techniques that I propose to be implemented as a stage in disaster relief so as to expedite the recovery phase following a natural disaster in hopes that it can be adopted in means of responding to other, and if possible, all forms of disaster relief.

TIMELINE AND RESOURCES

In order to obtain a feasible proposal for a structural method with a standard *building* being erected during the process of disaster recovery following a hurricane, I arranged my literary review and analysis in accordance with my personal design time as well as the composing of my thesis. Throughout my readings pertaining to the statistics and reconstruction of New Orleans and Galveston I am able to procure an understanding of what did and did not work in those particular emergency management situations. From interviews documented in articles as well as a personal diagnosis of the replacement buildings, I will be able to conclude what methods worked in the most and least efficient manner, the least being a proposition of omission and the most being taken into consideration for future implementation. All of these factors will be possible contributing elements to the final method and overall architectural design proposal for the reconstruction of a neighborhood in Staten Island after the catastrophic impositions of Hurricane Sandy.

In January, I visited Staten Island, New York and Belmar, New Jersey in order to gain a first-hand enlightenment of the damage as well as the procedures being conducted in order to recover the regions. Most of the rubble had already been relocated to the same landfill that consumes the remains of the beloved Twin Towers which fell victim to terrorism in 2001. Unfortunately, the portions of each neighborhood which received the worst damage were not open to the public and were guarded by armed officers at all times so as to ward off looters.

While in Staten Island, I was also able to locate a proper site along Kissam Avenue in the Oakwood Beach Neighborhood for the implementation of my structural proposition. The process will then be calculated based on available space, materials and capable community assistance. The final design was also a derivation of similar previous works in order to acquire validity, as stated earlier in the text. All data from my observations was collected and documented using my own personal equipment and documents in order to eliminate the strenuous implications of loans and reimbursements.

In addition to my trip to Staten Island, I also visited New Orleans, Louisiana, in order to evaluate the rebuilt houses and infrastructures as well as the overall progress of the Lower 9th Ward's recovery following the community's horrific experience. Considering that this site has undertaken all phases, from response to recovery, of disaster relief, I was able to determine the results of a completed process by personal examination. One of the biggest disappointments following my viewing of the Lower 9th Ward was the fact that despite the tremendous efforts from the MIR foundation, there are still hundreds of homes with roofs half torn off, completely gutted interiors revealing the structural bones, debris still throughout the neighborhood and horrible road conditions. This observational analysis provided a stronger motive to produce a probable solution to disaster recovery that utilizes prefabricated construction techniques in order to expedite the reconstruction phase. The data collected from either of these factors will provide me with material essential for generating my proposed alterations. The data collected from each of these visits will then be additional considerations for my final project, intermixed with the various methods and models presented in my reviewed projects built in response to natural disasters, dated modular arguments and procedures, and prefabrication projects.

SIGNIFICANCE, IMPACT AND FUTURE RESEARCH

With my research, I hope to bring to focus the need to readdress the procedures undergone in disaster relief in order to expedite the process as well as make it more efficient and effective. Once my concluding method and model are manipulated to their highest potential, the process undergone in order to produce the final result can be adjusted in order to adapt to remaining disasters. Since my proposed structure is focused on coastal projects, variables can be adjusted in order to evaluate the required criteria in means of producing a solution for, let's say a forest fire. The same suggested response methods may require minor alterations but the main evolution will be experienced by the permanent structures produced by the recovery phase. My belief is that a single standardized procedure would allow for an expedited response time, a structured addressing of the needs of the affected residents, and a sufficient start to the reconstruction of the victim's futures.

In addition to the adaptation of my proposed method upon all natural disasters, I also hope that my conclusion will possess key factors with the potential of being employed by emergency response to technological disasters. But as stated previously, until a system can improve a single response, we cannot expect or trust the procedure to protect us in all phases of all types of disasters. So with that, I present my proposal for the improvement of a single response with the intention of evolving the process to pertain to all phases of all types of disasters.

CHAPTER II

METHOD

In order to produce a viable solution for a prefabricated construction method within the phase of disaster relief so as to expedite the rebuilding of an area devastated following a coastal natural disaster, I will initially review the three costliest Atlantic hurricanes in the United States as well as the public criticism directed towards the disaster response efforts, beginning with the most expensive which happens to be the most criticized as well. Brad Pitt and the Make It Right foundation reveal the horrors that followed Hurricane Katrina within the Lower 9th Ward of New Orleans in their book *Architecture in Times of Need.* This text not only reviews personal negative encounters with FEMA but also shows in great details the houses designed in order to rebuild the devastated neighborhood as well as the designers. In addition to the criticism portrayed within this text, I will also review the work of Susan Cutter and Melanie Gall in their chapter entitled *2005 Events and Outcomes: Hurricane Katrina and Beyond* within the book *Emergency Management: The American Experience 1900 – 2010* which reviews not only the criticism of FEMA in regards to their response efforts following Hurricane Katrina but also the procedures undergone within the agency in means of improvement.

Once a thorough understanding of Hurricane Katrina's effect of the Lower 9th Ward and the criticism to the response efforts is established, I will then transition into the statistics regarding Hurricane Ike's destruction of Galveston Island. In their book *Infinite Monster: Courage, Hope and Resurrection in the Face of One of America's Largest Hurricanes*, Leigh Jones and Rhiannon Meyers reveal the hardships experienced by the residents who chose not to evacuate

due to a late mandatory evacuation as well as the lack of response from the federal government in means of assisting the area in not only recovery, but also immediate relief. I will then discuss the havoc wreaked by Superstorm Sandy on the Mid-Atlantic states as well as the current process and plans for reconstruction by reviewing works from Andy Newman in his article entitled *Hurricane Sandy vs. Hurricane Katrina*; Greg Smith in his article entitled *New Yorkers hit hard by Hurricane Sandy denied aid by FEMA* bureaucracy; and Yuko Okamura in her article entitled *Hurricane Sandy Update: The Post-Disaster Reconstruction Challenge.*

Following the descriptions of the three costliest hurricanes in Atlantic history in the United States, I will then refer to past arguments involving prefabrication methods and projects so as to gain a better understanding of past procedures. In order to do so, I will review Le Corbusier's book *Towards a New Architecture* where he argues the need for the construction of a house to be similar to that of a car manufacturer insinuating even then that a supply chain would improve the profession of architecture. Following Le Corbusier's work, I will then address Buckminster Fuller's Dymaxion House in Federico Neder's book *Fuller Houses: R. Buckminster Fuller's Dymaxion Dwellings and Other Domestic Adventures*. Though the project was never fully developed, it still possesses significant arguments which are relevant to current prefabrication procedures.

With past arguments having been analyzed, I will then transition to projects constructed in response to coastal natural disasters by referring back to Make It Right's process of rebuilding the Lower 9th Ward. Reviewed projects include the works from David Adjaye with Adjaye Associates, Gerald Billes and Richard Kravet with Billes Architecture, and Stephen Kieran and

James Timberlake from KieranTimberlake. To finalize my reviewed works, I will conclude with a project that I see as a beacon in prefabricated construction. In addition to their work with the MIR foundation, Kieran and Timberlake also constructed, or rather assembled, their project Loblolly House. Kieran and Timberlake designed this prefabricated masterpiece which consists mostly of off-site construction, "proposing a way to deliver quality architecture at a reasonable cost and in less time, through the use of prefabrication components" (Kieran, 2009). This project displays the substantial benefits when using building information modeling (BIM) techniques to fully design a structure, resulting in accurate predetermined materials and dimensions as well as less material waste and expedited assembly, all of which would be sufficient contributions to a natural disaster recovery process.

With this information, I will then transition into the selection process within my proposal undergone by the client who lost their home following the destruction of a natural disaster; in my particular case, Staten Island after the destruction of Superstorm Sandy. This information as well as the inspirational arguments, techniques and procedures will then allow me to generate a viable solution for a prefabricated construction method within the phase of disaster relief so as to expedite the rebuilding of an area devastated following a coastal natural disaster. And with the proposal of this prefabricated standard, I intend for the design to act as a template that can later be adjusted in means of meeting the demands of areas devastated not only by hurricanes, but other natural as well as technological disasters still to come.

CHAPTER III

THE THREE COSTLIEST HURRICANES IN UNITED STATES AND THE CRITICISM TO THE DISASTER RESPONSE EFFORTS

On August 29th, 2005, New Orleans, Louisiana was tormented by the worst natural disaster in Atlantic history. Hurricane Katrina struck the Mississippi coastline early that Monday morning and left behind $81 billion worth of damages. The devastation began around 5 o'clock that morning when "Hurricane Katrina's low pressure and residual Category Five surge penetrated the MR-GO/Intracoastal Waterway 'funnel,' overtopped meager levees, and introduced gulf water immediately behind the Lower 9th Ward and St. Bernard Parish" (Campanella, 2009). In other words, the levees never even stood a chance and their failure caused the water level in the Industrial Canal to rise fourteen feet above normal levels. To continue in the play-by-play procedure of the failing levees, author and New Orleans geographer, Richard Campanella explains that "around 7:45 a.m., a massive section of floodwall collapsed and sent a violent torrent of brackish water eastward into the Lower 9th Ward homes. Flood Levels rose by ten feet in twenty minutes," tearing houses from their foundations, erasing blocks upon blocks, ultimately leaving entire communities homeless as the water swept through the community (Campanella, 2009).

By August 2010, the total reconstruction costs had tallied up to $157 billion, which makes it fair to assume that Hurricane Katrina also ranks as the costliest event in these terms considering that "roughly ninety thousand square miles in parts of Alabama, Louisiana, and Mississippi – an area slightly larger than that of Great Britain – were devastated" (Cutter and Gall, 2012). As if the price tag on this natural disaster wasn't overwhelming enough, the more disturbing matter is that

studies show that the disaster was in fact not entirely natural but actually magnified by decades of neglect.

Professor of history at Rice University, Douglas Brinkley addresses how "harrowing descriptions about how the U.S. Army Corps of Engineers erected Lego levees in 1965 thereby casting a time-box pox over entire New Orleans neighborhoods like the Lower 9th is now an accepted fact" (Brinkley, 2009). With little to no order in their method, the U.S. Army Core of Engineers proceeded to simply stack blocks upon blocks of concrete in a random fashion. Aware of the fact that the levees needed to be rebuilt in order to withstand disastrous conditions, city leaders chose to procrastinate in the reconstruction. This negligence resulted in fifty-three levee breaches and the deaths of over 1,000 people in the Lower 9th Ward alone. Actor and founder of the Make It Right foundation, Brad Pitt goes on to claim that "decades of reckless handling of the levees combined with a negligent lack of political effort to rectify issues that were common knowledge would ultimately kill more than 1,800 people" and that "the most sickening thought is that this all could have been avoided" (Pitt, 2009).

However, the levees were not reconstructed prior to the disaster and therefore, the troubling results were not avoided. Following the disaster, it was later determined that "eighty percent of Greater New Orleans was flooded" at depths up to twenty feet which resulted in 243,180 people living in houses with over four feet of flood water, accounting for fifty percent of the city's population. In addition to the eminent fact of water damage within the residence, it was later determined that the flood waters were highly toxic and that "many people continue to suffer from lingering effects of this contamination" (Feireiss, 2009). In the days to follow, the people of the

Lower 9th Ward endured temperatures in excess of 100 degrees Fahrenheit and almost 100 percent humidity "for days on end without electricity, without water, and ultimately, without hope" (Feireiss, 2009). Editor of *Architecture in Times of Need,* Kristin Feireiss goes on to explain how "neighbors tell stories of devastating heat, desperate attempts to save family members by hacking holes through roofs to provide air and escape from the fetid floodwaters, hours upon hours, days upon days on rooftops without drinking water in the relentless sun waiting for help. And the wait goes on more than three years later."

Following the devastation of Hurricane Katrina, the Federal Emergency Management Agency (FEMA) received substantial criticism in regards to their preparedness prior to the disaster as well as their response time following the destruction. Campanella expresses his opinions on this matter by stating that "the [Lower 9th Ward] ranked unquestionably as the hardest-hit of the entire metropolis, and, not surprisingly, as the last to see utilities, municipal services, and residents return" (Campanella, 2009). So not only were the damages, for the most part, preventable in the Lower 9th Ward, they were also the most severe in this area; but even with this information, the federal government still was slow in responding to the cries for help. Pitt addresses this issue by calling out those responsible when he stated that "this is an issue of social justice, and a responsibility exists to right this wrong. Our first response in a crisis should be to help those who are most vulnerable and at this we failed – failed miserably. Most would say we continue this failure throughout the recovery effort" (Pitt, 2009).

Pitt eventually responded to the call for help in the Lower 9th Ward by establishing the Make It Right foundation which will be reviewed in the cited projects portion of this paper. Now that the

damage caused by Hurricane Katrina has been addressed, I will now review the criticism of FEMA's response efforts.

President of Claire B. Rubin and Associates in Washington D.C and editor of *Emergency Management: The American Experience 1900 – 2010*, social scientist Claire B. Rubin compared the overall effects and response procedures following not only Hurricane Karina but also Hurricanes Rita and Wilma to the September 11th terrorist attacks in New York. Rubin claimed that "the 2005 hurricanes did for natural disaster response what the terrorist attacks on 9/11 did for counterterrorism. Both glaringly displayed the weakness and failures of certain emergency management systems, process, and leadership" (Rubin, 2012). She then went on to directly criticize the emergency response efforts to Hurricane Katrina by stating that the efforts were "so inadequate that government officials at all levels were humiliated at home and abroad" (Rubin, 2012). These statements exemplify the notion of Hurricane Katrina being just as much of a human catastrophe as it was a natural disaster. Director of the Hazards Research Lab at the University of South Carolina, Susan Cutter, and Professor, Melanie Gall emphasize on this notion when they address the fact that "the overwhelming extent of disruption and destruction at all levels of emergency management, and particularly during the preparedness and response phases, made Hurricane Katrina a human catastrophe as well as a natural disaster" (Cutter and Gall, 2012).

Unfortunately the shortcomings of a city government not prepared for the third deadliest hurricane were made evident in the community's attempts to provide their own relief through the efforts of individuals. Cutter and Gall go on to explain how "almost instantly, informal, prosocial

behavior emerged among the storm's survivors to organize rescue operations, retrieve survivors, and provide relief. Likewise, first responders improvised to find and evacuate as many people as possible, as well as to provide emergency health care to those in need" (Cutter and Gall, 2012). These impromptu attempts, though acclaimed, could not meet the demands caused by the destruction. The informal organizations soon realized that the evacuation route was either made impassible from congested traffic or rising floodwaters; the improvised search-and-rescue teams were not only unprepared but also understaffed; the sick and elderly were stranded in hospitals and nursing homes, and the last resort sheltering offered within the Superdome suffered from unacceptable living conditions. "For days, the entire disaster area was without food, potable water, power, medication, sanitation, adequate sheltering, and any form of organizational help" (Cutter and Gall, 2012). All in all, "FEMA failed to fulfill its responsibilities as the leading coordinating emergency management institution. It failed to coordinate military and international assistance, compounding grossly inadequate and chaotic provision of commodities, emergency sheltering, and temporary housing" (Cutter and Gall, 2012).

One of the difficulties encountered when attempting to execute emergency management techniques within the U. S. occurs when solutions conceptualized at the federal level are implemented onto local and state governments without proper resources or knowledge. These top-down solutions are meant to "equip local emergency agencies with resources, capacities, and knowledge to proactively manage and respond to emergencies" but the enforcements made by the federal government may cause a lack of preparation and mitigation that can be better executed at the local level (Cutter and Gall, 2012). This federal assurance may also lead to an increased reliance on the federal response which can ultimately result in the local community

forming unrealistic expectations for emergency response. “FEMA’s top-heavy bureaucracy may be part of the problem; some policy analysts argue for the decentralization of emergency functions and the strengthening of local capabilities” which makes sense due to the fact that in any natural event, the local authority is and always will be the first and last respondents on the scene (Cutter and Gall, 2012).

In response to the devastation caused by Hurricane Katrina, the federal government made numerous adjustments in the procedures and positions of authority within emergency management but even with the rigorous reassessments, “no major improvements [have been made] in the nation’s critical infrastructure, hazard mitigation, environmental regulation, catastrophic planning, or medical preparedness” (Cutter and Gall, 2012). In terms of adjusting the positions of authority within emergency management, however, former FEMA director and Michael Brown was stripped of his position overseeing the relief efforts and was replaced by federal official and former firefighter R. David Paulison. One of Paulison’s first reassessments to emergency management was to “increased its cache of relief supplies to be able to sustain an estimated one million people for seven days” (Cutter and Gall, 2012).

Unfortunately, as shown in a later portion of this paper, this increase of relief supplies was nowhere to be seen following the destruction of Hurricanes Ike and Sandy. One reason for this shortcoming could be due to the fact that “while the White House issued a *Roadmap for Restoring Ecosystem Resiliency and Sustainability* in 2010, there is still no national recovery plan to regulate comprehensive issues related to individual, corporate, institutional, infrastructure, and environmental recovery” (Cutter and Gall, 2012). Instead, there exists only a

set of principles that the local and state government are subjected to follow in response to a disaster. In other words, the national government upholds a lenient regulation in certain areas of emergency management while maintaining an overall responsibility in a holistic manner.

Nearly three years after the havoc wreaked by Hurricane Katrina, the United States gulf coast was under threat of another natural disaster, making it the fourth to threaten the Galveston area that year. Hurricane Ike made its way into the gulf coast early September 2008 but originally, the forecasters predicted the storm to head south, causing the residence of Galveston Island to postpone their storm preparation. Meteorologist Gene Hafele and his team of twenty-four forecasters declared the Tuesday (September 9th) before Hurricane Ike made landfall that the storm was heading south towards Brownsville, leaving Galveston in the "near miss" category. This came as a relief to the forecast team considering the fact that this would be the fourth hurricane to threaten Galveston's shoreline with equivalent possibilities of escaping the natural disaster as they had three times prior that year. So instead of preparing evacuation routes and warning residents to gas up their cars, "the state's emergency management coordinators ordered all of the evacuation buses and fuel tanker trucks to head south down the coast" (Jones and Meyers, 2010). Yet Hafele couldn't help but think that officials were letting their guards down too quickly and proceeded to keep residents informed of the possibility of change by inserting remarks in his forecast stating "even though it look[s] like it [will] go south, we [are] still four days out and a lot [can] change" (Jones and Meyers, 2010).

Regardless of Hafele's concerns, the residents of Galveston Island decided to remain on the island "unless they could be absolutely sure the threat of staying outweighed the frustration and

inconvenience of leaving" (Jones and Meyers, 2010). By Wednesday**,** the storm was projected to make landfall 100 miles south of Galveston which put the low-lying area of the West End in threat of moderate flooding. In response to the evident threat, Mayor Lyda Ann Thomas requested a mandatory evacuation of the 20-mile long, skinny half of the island unprotected by the 17-foot seawall. By Thursday, Ike had turned north again which projected Galveston as being uncomfortably close to the landfall.

Finally at 9 am that Thursday, Mayor Thomas ordered a mandatory evacuation of the entire island. During the city's 4 pm advisory, the National Weather Service announced that Ike was projected to move directly over the urban core of Galveston where it made landfall early Saturday morning. Even so, 20,000 residents decided to remain in Galveston and face Hurricane Ike on their own, leaving the minority of 1,500 residents accepting the offer to be bussed to Austin. By early Friday morning, the West End was already witnessing early symptoms of Hurricane Ike. "The hurricane – still more than a day away according to the National Weather Service forecast – funneled a storm surge into the streets, transforming the roads in the tiny village of Jamaica Beach into miniature canals" and the waves were already crashing 15-feet high upon the seawall, leaving only 8-feet before the water starts spilling over (Jones and Meyers, 2010).

Hurricane Ike finally made landfall in the middle of the night of September 13, 2008 with its initial surge topping "sewage treatment plants and water pumping stations. Generators powered by natural gas sputtered to a halt when the gas company unexpectedly shut off all service to the island to prevent explosions at ruptured pipes. Galveston had no running water and no source of

power. Raw sewage ran into Galveston Bay" (Jones and Meyers, 2010). Bolivar Peninsula suffered the worst damage. Despite the houses being built on stilts, the storm surge still proceeded to blow out walls from houses and in some cases, completely level neighborhoods. U.S. Coast Guard Lieutenant John Moran noted that, "eighty-five to ninety-five percent of the peninsula [was] destroyed" and that "only ten to fifteen percent of the houses [were] left standing" (Jones and Meyers, 2010). Also, the storm surge managed to divide the Bolivar Peninsula into three small islands, making the space impossible to access without the use of boat or helicopter. Once the damages were tallied up, Hurricane Ike was ranked the third costliest Atlantic hurricane under Hurricane Katrina and Sandy, totaling $29.5 billion worth of damages.

Following the mandatory evacuation, all plans for refugee storms shelters were discontinued. What originally consisted of four schools with the capability of safely housing about 4,000 refugees was reduced to reliance solely on one school to act as *the* shelter. In response to the steadily increasing numbers of remaining citizens, Galveston Independent School District Superintendent Lynne Cleveland opened Ball-High School to act as the emergency shelter for families able to reach the doors. But even with a safe haven for the remaining residents without a home, Galveston Island was rapidly becoming a public health hazard. "Toilets hadn't been flushed in days. Sewage bubbled out of storm drains and no one could bathe. Without electricity or natural gas, islanders couldn't cook, power refrigerators, or run air conditioners in their dangerously hot and humid houses" (Jones and Meyers, 2010). The flood forced the island's only hospital to be shut down, leaving minor abrasions to be treated by federal disaster medical assistance team at Ball High-School while patients requiring serious medical attention were sent

to hospitals as far away as Houston. But even with these devastating conditions, only six people died on the island and of those six, two drowned in the surge.

In the days following the storm, **"**Galveston's City Council declared a state of emergency and put Mayor Thomas in charge of the city. Under the declaration, the island effectively became a dictatorship, with only one person calling the shots" (Jones and Meyers, 2010). Mayor Thomas began reaching out for any assistance she could find, especially in means of housing those who remained on the island with no safe place to live. By late October, there were still 200 residents with no place to live and with no room available in temporary housing, a statewide social service agency managed to create a new shelter for the remaining refugees at Scholes International Airport. Other refugees resided in hotels subsidized by FEMA but "every time an assistance deadline approached, the federal government threatened to toss them out" (Jones and Meyers, 2010). Once evicted, those who had nowhere else to go were rendered homeless.

Mayor Thomas did all she could to alleviate the citizens of Galveston Island of the living conditions, most of which were overcrowded, within the subsidized hotel, going so far as to "publicly [pleading] with FEMA to give Galveston 500-two bedroom trailers for its neediest residents," but after six months, the agency was only able to provide fifty-four. In addition to this inadequate response, the temporary trailer park did not open until March 12, six months after the storm, and although 961 families remained in hotel rooms paid for by the federal government, only 29 qualified under the agency's rules to move into the trailer park (Jones and Meyers, 2010).

In response to the severity of these two horrific hurricanes along with the criticism of the disaster relief efforts by FEMA, I propose a standard disaster recovery phase that utilizes prefabricated construction techniques to take place simultaneously with disaster relief efforts following the devastation of a natural disaster. The standard protocol can always be adjusted in order to meet the demands of the particular disaster but the standard must first be created. The result would ultimately lead to a more efficient response and recovery phase in disaster relief considering the fact that making adjustments to a plan is much easier to accomplish than starting a new plan after every disaster.

However, on October 29, 2012, the deadliest and most destructive tropical storm of the 2012 Atlantic hurricane season struck the eastern coast of the United States and wreaked havoc on the Mid-Atlantic states, namely New York and New Jersey. Considered "the forgotten borough" by many residents even before the devastation of Hurricane Sandy, Staten Island lies in a state of great despair with the vulnerability of impeded recovery. With a population of about 470,000, Staten Island remains one of New York City's smallest boroughs but suffered the highest casualty rate: 23 of the city's 43 deaths. In the aftermath of Superstorm Sandy, FEMA received more praise than criticism from officials. Hurricane Sandy, later nicknamed Superstorm Sandy after the tropical storm's mergence with a frontal system, destroyed approximately 305,000 housing units in New York alone, making Superstorm Sandy the second costliest hurricane in the United States' history, with damages estimated at $71 billion in New York and New Jersey alone (Newman, 2012).

As stated earlier, FEMA's response efforts following the devastation of Superstorm Sandy were commended, at least by officials. New York Daily News reporter, Greg Smith stated that "this time around [FEMA's relief efforts] received more praise than criticism from officials" but went on to explain how "animosity toward the agency [seemed] to swell in waterfront areas most affected by the storm" (Smith, 2012). The animosity came from residents who seem to be having extreme difficulties being approved for housing help from the agency. Public Advocate, Bill Blasio claims that the system is "much more complicated than it needs to be" and encourages FEMA applicants to appeal denials (Smith, 2012). The issue stirs from homeowners attempting to determine what is and is not covered by insurance, considering that anything that is covered by private insurance is not covered by FEMA. Superintendent of the state department of Financial Services, Benjamin Lawsky also believes that the issue is due to there not being enough insurance adjusters and homes not getting inspected enough and stated that even though FEMA encourages homeowners to file quickly, "with no adjuster showing up to sign off, FEMA automatically sent out denials" (Smith, 2012).

Even so, this seemed to be the largest issue considering FEMA's response efforts following the destruction of Hurricane Sandy, making it a considerable improvement when considering the criticism following Hurricanes Katrina and Ike. Research Associate, Yuko Okumura acknowledges that there are already programs working towards reconstructing destroyed homes. With fourteen years of experience in rebuilding disaster-affected areas, Architecture for Humanity's Reconstruction and Resiliency team are working towards long-term reconstruction "by talking to community members, assessing damages and meeting with town officials" and have dedicated themselves to "helping communities by assisting families and community leaders

navigate the reconstruction process" (Okumura, 2012). Within the Architecture for Humanity's Reconstruction and Resiliency team is the Hurricane Sandy Reconstruction Program which has created two separate programs to also assist in the reconstruction phase. The *Restore the Shore* and *Rebuild One Block* has answered the call to action by focusing on the "rebuilding of important centers of the community such as schools, small businesses, senior centers and housing" (Okumura, 2012).

Though these programs are extremely useful in terms of assisting the affected communities in the reconstruction of their destroyed homes, I still believe that the implementation of a standardized rebuild phase within disaster relief efforts immediately following the natural disaster would ultimately lead to an expedited recovery. Yet in response to the severity of these three horrific hurricanes along with the criticism of the disaster relief efforts by FEMA, I propose a standard disaster recovery phase that utilizes prefabricated construction techniques to take place simultaneously with disaster relief efforts following the devastation of a natural disaster. The standard protocol can always be adjusted in order to meet the demands of the particular disaster but the standard must first be created. The result would ultimately lead to a more efficient response and recovery phase in disaster relief considering the fact that making adjustments to a plan is much easier to accomplish than starting a new plan after every disaster. In order to determine a viable procedure and prefabricated model, I will review previous works that act as inspiration for my conclusion.

CHAPTER IV

LEARNING FROM THE PAST

Swiss architect and a pioneer in modern residential designs, Le Corbusier supported the notion of utilizing the available tools of the time to their full potential. With every advance in a tool, or in modern terms, technology, there should be a simultaneous advancement in the industries. Le Corbusier expressed his view on this notion when he states that "tools are the result of successive improvement; the effort of all generations is embodied in them. The tool is the direct and immediate expression of progress; it gives man essential assistance" (Corbusier, 1927). Le Corbusier is referring to the essential tools developed through the industrial revolution and that with these new tools, progress should occur accordingly.

Le Corbusier goes on to explain how "it is not right that we should produce bad things because of a bad tool; nor is it right that we should waste our energy, our health and our courage because of a bad tool; it must be thrown away and replaced" (Corbusier, 1927). Though the tool may not be literally thrown away, Le Corbusier is expresses the need for improvements of available resources so long as the time is able of doing so. Considering the current available tools in the profession of architecture to be utilized in my proposal, one of the most efficient resources is the use of Building Information Modeling (BIM) technology which allows the designer to generate structural and functional elements into the original digital model. In other words, the designer can not only determine the specific materials and utilities a house can have, but also the exact dimension required so as to minimize material waste.

However, Le Corbusier criticizes the architectural profession of his time for not utilizing the available tools and advancing their construction procedures and deems the profession stagnant. Le Corbusier expresses this notion by claiming that "there is one profession and one only, namely architecture, in which progress is not considered necessary, where laziness is enthroned, and in which the reference is always to yesterday" (Corbusier, 1927). Though this is a rather bold statement, the point is clearly made and unfortunately reflects with the current status of the architectural profession. Though we have the available resources to evolve from traditional construction techniques, we still proceed to produce the same mass public-housing, leaving good design to "service the upper and upper-middle class, generating the perception that it is an elitist pursuit" (Pitt, 2009). And though public housing projects rapidly provide affordable housing solution, they also "imperil diversity, suppress the human spirit, and obfuscate the means to establishing dynamic communities" (Norheim and Putz, 2009). To further add to his disappointment, Le Corbusier goes on to state that the external world has "gained a new perspective and a new social life, but [has] not yet adapted the house thereto," meaning that while other industries flourish with the production of new technologies, architecture remains immobile.

In response to his perceived status of architecture, Le Corbusier suggests evolving the profession to be more like the automobile industry, producing individual components in a factory that can later be assembled into a whole. He further develops this notion by focusing on one single component of a vehicle: "if the problem of the dwelling or the flat were studied in the same way that a chassis is, a speedy transformation and improvement would be seen in our houses. If houses were constructed by industrial mass-production, like chassis, unexpected but sane and

defensible forms would soon appear, and a new aesthetic would be formulated with astonishing precision" (Corbusier, 1927).

Le Corbusier goes on to explain that by constructing houses by industrial mass-production, we would be able to determine a standard which could result in a maximum output from a minimum input: "the establishment of a standard involves exhausting every practical and reasonable possibility, and extracting from them a recognized type conformable to its functions, with a maximum output and a minimum use of means, workmanship and material, words, forms, colors, sounds. The motor-car is an object with a simple function (to travel) and complicated aims (comfort, resistance, appearance) which has forced on big industry the absolute necessity of standardization" (Corbusier, 1927). In other words, establishing a standard involves the most efficient process of assembling a car as well as the procedures for procuring the best outcome and by adapting this standard to meet the demands of architecture, the profession would flourish likewise. As stated previously, if a standard can be adopted by disaster relief efforts in means of producing a set reconstruction procedure, the recovery phase would also be able to maximize its efficiency.

However, Le Corbusier was aware that his generation did not possess the technology to accomplish this task and believed that "in the next twenty years, big industry will have coordinated its standardized materials, comparable with those of metallurgy; technical achievement will have carried heating and lighting and methods of rational construction far beyond anything we are acquainted with" (Corbusier, 1927). It has been nearly 82 years since the publication of this book and so far, big industry has only impeded the housing industry with

contracted neighborhoods built by means of quantity rather than quality. We have achieved great things, especially in means of heating and lighting as well as energy efficiency, yet with our available resources we possess the capability to produce great and sustainable things but only minority of our profession chose to do so.

Not long after Corbusier's English addition of *Towards a New Architecture*'s publication, architect and inventor Buckminster Fuller completed his aerodynamic and machine driven Dymaxion House. After two years of development, the Dymaxion House was Fuller's first developed project, derived from his research on efficient, affordable, and prefabricated housing. The house was suspended by steel cables from a single mast that ran utility lines up through the center of the hexagonal structure. The exterior consisted of a metal aerodynamic cladding, protecting the utilities and potential residents within. The interior of the house was meant to provide for the client's everyday needs while simultaneously distracting the resident from the tessellated surfaces and interior machines by using the furnishings as masking elements and is best described by New Zealand architect, Mark Wigley (Figure 1):

> Every aspect of the space challenged the familiar look, feel, performance, construction, and economics of a house, from its inflated tubular metal structure to the see-through vacuum-sealed outer wall panels of recycled vegetable material, the spongy inflated bladder floor, the pneumatic partitions, the inflatable furniture, the glass tables suspended by neon-lit cables, the molded bathroom unit with atomized spray, the photoelectrically controlled revolving storage units, the pneumatic silver balloon silk doors, and the triangular curtains pulled up from the floor and down from the ceiling. The triangle is the basis of "dymaxion designing" in opposition to the traditional "linear" approach. Its inherent stability is used to destabilize the field, enabling the house to be mobilized into something else altogether. Within the structure's resilient geometric web, all dust, smells, and sounds are continuously removed, temperature and humidity is regulated, cooking and laundry are automated, and the whole ceiling acts as a single continuously adjustable diffuse light fitting and heat control (Neder, 2008).

Figure 1: Dymaxion House Interior (This image is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported License for public use and redistribution.)

So as stated before, the house was literally designed to meet the everyday needs of the resident without any form of action, all the way from doing the laundry to removing the foul odor in the bathroom. In addition to these amenities, the Dymaxion House structure was designed as a "construction similar to an airplane: light, taut and profoundly strong" which allowed the structure to transfer the loads from the walls to instead rely on the central mast (Neder, 2008). This made it possible for Fuller to replace the massive supporting walls with "machines for storage" (Neder, 2008). Architectural researcher, Federico Neder thoroughly explains this procedure by stating that "the suspension type construction of the Fuller House frees all interior walls from load-bearing functions. All partitions, therefore, are hollow and utilized to provide ample storage, closet, and shelf space" (Neder, 2008). By achieving available space where a structural wall should be, Fuller claimed to have expanded the client's use of a wall from strictly being a place to hang photos to pre-installed storage units.

Fuller's Dymaxion House was designed to take form step by step, as in a children's game. The ultramodern exterior shell was intended to double as the "container in which the component parts of the house are stored and transported to the building site (Figure 2). The interior fittings, bathrooms, and storage areas that function as room dividers are then subsequently installed

within the house" simplifying the construction phase so that the house could be readily assembled by non-specialized workers (Neder, 2008). This is an essential tactic when considering disaster recovery efforts due to the fact that the utilization of prefabricated elements requires assembly, which most people can do with a set of instructions, rather than construction, which traditionally requires years of practice to perfect. Unfortunately, the Dymaxion House was unable to accomplish this goal. When attempting to simply display the Dymaxion House in the Henry Ford Museum in 1998, instead of lasting the two working days that Fuller claimed, the reassembling of the Dymaxion House took three years and required extensive research in order to piece together the abandoned prototype.

Figure 2: Dymaxion House Exterior (This image is licensed under the Creative Commons Attribution-Share Alike 3.0 Unported License for public use and redistribution.)

When the Dymaxion House was presented to the public it received significant praise from the general public but Fuller had a much harder time convincing potential professional investors. Neder goes on to explain how "the house of the future was a utopian vision addressed to an audience with little technical knowledge. While attractive to a general public, Fuller's models, drawings, and lectures were less effective in capturing the interest of a more skeptical audience of architectural professionals" (Neder, 2008). Even so, Fuller received 3,500 orders from across

the country for the Dymaxion House, or iteration thereof. But to the client's disappointment, "numerous questions awaited resolution, including construction details as well as logistics of production and distribution" which resulted in only two houses leaving the factory (Neder, 2008).

In the end, the skepticism received from people within the architectural profession proved to be true, yet I too would be skeptic to invest in a house that claims to freshen itself after someone abuses the toilet considering that automobiles had just recently started being massed produced nearly 30 years prior to Fuller's proposal. The installed amenities were, to be truthful, impractical, and this could be a reason as to why the Dymaxion House never took off. Had Fuller focused more on the prefabricated aspect with the ease of assembly and the elimination of traditional construction methods rather than a house that cleaned for the residents, the project may have been produced in large numbers and actually able to assemble and disassemble. Fuller never addressed the notion, but he seemed to have experienced the same hindrance as Le Corbusierin terms of his generation not possessing the technology to accomplish this project. Regardless, Fuller was aware that he implementation of these beneficial techniques had the potential to ultimately lead to an ease of purchase and implied the utilization of sustainable systems and prefabricated structures, which today is common knowledge but still remains a minor influence in the overall scale of construction, though its relevance is steadily increasing. Though the Dymaxion House never reached its maximum potential or expectations, it was and still is viewed as "a container enclosing a series of still-pertinent ideas on the house of the future" (Neder, 2008). Today, we are not only well aware of these ideas and their benefits in

regards to the environment, we also have the technology to successfully implement them into society.

Recent projects have not only adopted a prefabricated construction method but also utilized sustainable materials and utilities. I will begin by reviewing works conceived and produced by organizations in response to the natural disasters discussed earlier and then transition to a project which has the potential to be a catalyst in not only prefabrication methods but in the architecture industry as a whole.

CHAPTER V

REBUILDING THE LOWER 9TH WARD OF NEW ORLEANS

In response to the fact that "the government [had] been slow to provide assistance to those who wanted to return – and the assistance they [were] providing [was] inadequate to replace the homes that were destroyed, modest as they were" in the Lower 9th Ward following the devastation of Hurricane Katrina, actor Brad Pitt, with the help of Neiel Norheim and Wolfram Putz from GRAFT Architects and numerous other contributors, founded the Make It Right (MIR) foundation in order to rebuild the destroyed community (Killeen, 2009). With the founding of the MIR, the organization was determined to set a precedent "which could become an inspirational role model for raising awareness, engaging interest, and engendering rebuilding in areas which had been most affected by the Katrina catastrophe" (Norheim and Putz, 2009). In order to accomplish this potential catalyst in disaster response, MIR made it their goal to ultimately rebuild 150 homes and have successfully completed 86 homes, all of which have earned LEED Platinum which is the highest level of certification for Leaders in Energy and Environmental Design offered by the U.S. Green Building Council. All proposed houses needed to be "safe, affordable, sustainable prototypical single-family home[s]" (GRAFT, Pg. 85) and once a system was generated, "a template [remained] for a system which [could] be utilized for disaster relief in other parts of the world suffering similar devastation" (Norheim and Putz, 2009). All of this was made possible by creating "intelligently designed architectural solutions, environmental [responsibilities], community outreach programs, creative financing strategies, fundraising initiatives, and construction management strategies" (Norheim and Putz, 2009).

When addressing the traditional styles and techniques found within the architecture of the Lower 9th Ward, Executive Director at Lime Agency for Sustainable Hot/Humid Design Partner at Prosus Design, Carrie Bernhard explained that most of the residents of the Lower 9th Ward lived in townhouses, courtyard houses or cottages which "were imported as the building traditions of the various cultures that settled in the city" (Bernhard, 2009). These traditional designs were then altered in order to adapt to the local site and climate conditions as well as the cultural exigencies of the time. These adaptations ultimately lead to the Creole Townhouse, which "is characterized by a linear succession of primary spaces and vertically oriented circulation;" the Creole Cottage, which "is characterized by a succession of primary spaces off the street followed by a succession of attached secondary spaces;" and the Shotgun, which "is characterized by a linear progression of spaces aligned perpendicularly with the street" being the ubiquitous house types of New Orleans (Bernhard, 2009). Bernhard goes on to claim that "the simplicity of these houses, in form and organization, allowed for easy replication and the potential for multiple variations" (Bernhard, 2009).

Though different in design, each of these houses maintained similar characteristics. The interior of the houses usually had tall ceilings with windows, dormers, or vents to allow heat to rise and be drawn from the room, otherwise known as stack ventilation. Also, most of the openings in the homes were located across from one another in order to allow for cross ventilation. And by arranging the circulation through the house without the use of corridors, the residents were able to maximize their living area. In terms of my proposal for a standard recovery procedure that utilizes prefabricated construction techniques, I too will generate a simple form and organization

allowing for easy replication with the ability to generate multiple variations, all the while providing a maximum living area that can be cross ventilated.

MIR made it their goal to derive their designs from the original housing styles that were destroyed by Hurricane Katrina. In addition to maintaining traditional values and styles, MIR also wanted to express the importance of the client's choice when selecting their new homes. Members of MIR participated in lengthy discussions with the residents of the Lower 9th Ward. Their main concern was to address the victim's lifestyles, fears, personal values, their definition of community, their optimism in the revitalization of New Orleans as well as their longing desires simply to come home. Norheim and Putz emphasized the relevance of the client's choice by stating that "one of the strongest countermeasures that can be provided to the individual is the power of choice. The process of selecting their house design provides an outlet for control to be returned to the landowner; it offers the expression of individuality, pride, and difference. Homeowners always have the final say in which designs would be built" (Norheim and Putz, 2009).

MIR reached out to architecture firms all over the world, including Adjaye Associates, Billes Architecture, KierenTimberlake, GRAFT, MVRDV, Gehry Partners, LLP, and many more. The design parameters were simple: produce high design at a low cost. Also, in order to ensure that equivalent destruction would not occur after the hurricanes and other disasters still to come, Norheim and Putz generated criteria for homes' survivability:

> Houses had to be raised to either five or eight feet above grade level, most of which are eight: houses had to be built in order to withstand severe weather conditions such as hurricanes and flood surges: the chosen materials for the homes were required to be able to resist water damage and molding: hurricane-resistant roofing, siding, and window

> systems should also be utilized in order to make the homes able to withstand disastrous events: and the roofs had to also be equipped with a raised patio that could be used as a safe haven in flood threatening conditions (Norheim and Putz, 2009).

These criteria will strongly be taken into consideration when determining the materials for my final residential model to replace the homes destroyed by Hurricane Sandy in Staten Island.

"After a period of thorough design charrettes, value engineering, and prototype testing, the first houses were occupied by their new (and mostly former) owners" around the third anniversary of Katrina in August 2008 (Feireiss, 2009). In addition to providing community members of the Lower 9th Ward who had lost their homes with a new residence, Executive Director of MIR, Tom Darden explained how they also offered "homeowner counseling is the process through which Lower 9th Ward residents who work with MIR choose, finance, and prepare to own their new homes" (Darden, 2009). In order to assist the new homeowners finance their houses, FSG Consultant, Ajamu Kitwana described how MIR provided "'gap' financing to cover the difference between the home price and funds available to the property owner" in the form of forgivable loans" (Kitwana, 2009).

British architect, David Adjaye and Adjaye Associates designed a house that was directly derived from the Shotgun house. In addition to that traditional layout, Adjaye added a reinforced foundation in order for the house to be capable of withstanding additional forces of hurricane winds and flooding. Well aware of the use of filigree patterns within the exterior railings of balconies that can be found on majority of New Orleans homes, Adjaye was also able to adopt this traditional design into a storm screen that protected windows and indoor spaces. In order to make the house efficient and sustainable, Adjaye decided to invert the typical pitched roof into a

solar and water collector, offering the roof as a shaded terrace which he claims is a "responsible design for long-term environmental benefits" (Adjaye, 2009). Though Adjaye's ability to adapt New Orleans' traditional Shotgun style into a modern and sustainable design, which is a procedure that I intend to implement within my design, I do however understand the expenses required within the use of solar panels and a roof terrace and intend to replace these materials with a more cost-efficient procedure.

Founder of Billes Architecture, Gerald Billes and architect Richard Kravet also produced a prototype for MIR that was a balance between the use of traditional construction methods using local resources and modern technology systems that are durable, low maintenance, and contribute to lowering utility bills. Billes goes on to explain that "the design utilizes natural ventilation, controlled daylighting, high ceilings with fans, shading devices, and thermal mass in the same manner as traditional New Orleans architecture" (Billes, 2009). As Billes did within his design, my prototype for Staten Island residents will also utilize natural ventilation techniques as energy efficient utilities, though in lieu of traditional techniques, my designs will instead use prefabricated construction methods.

One of the most prominent designs, in my opinion, proposed for a displaced resident of the Lower 9th Ward was designed by architects and founders of KieranTimberlake, Stephen Kieran and James Timberlake. The goal within their prototype was to produce a first-generation home though prefabricated construction methods that could later be adjusted, by preferences of the client, to create second, third, and however many more generations from the original design. Kieran best explains this procedure by stating:

> The proposed design is a flexible, integrated system developed to accommodate a range of customizable options from interior program to environmental systems to aesthetics. The design anticipates a transition from stick-built construction in the first generation to local off-site fabricated subassemblies in later generations. The basic structure and organization of the house is comparable to the chassis of an automobile fitted with optional components and assemblies that vary the specifics of its function and its appearance. Through selection of options the house is readily customized to satisfy a range of conditions and desires. Homeowners are encouraged to deploy this array of variables as they see fit. The architects see this approach as essential toward rebuilding a neighborhood and not simply providing shelter (Kieran, 2009).

This process not only balances program and systems with aesthetics but is also able to adjust to fit the desires of the homeowners, both of which are procedures that I intend to implement into my final design. And just as Kieran and Timberlake's original prototype can be converted into second and third generations, my design will be a standard layout that can be adjusted in means of meeting the client's requests, but as stated before, there must first be a standard.

Kieran and Timberlake completed their first prototype in 2008 and since then have constructed, or rather assembled, four generations of the original design. However, just a year prior to this design, Kieran and Timberlake constructed another prefabricated home that follows the same principles which I personally see as a beacon in terms of prefabricated construction techniques.

CHAPTER VI

PREFABRICATION: FROM CONSTRUCTION TO ASSEMBLY

In 2007, Kieran and Timberlake sought to produce a project that could be seen as a catalyst in the prefabricated construction industry in means of veering the profession of architecture from its traditional construction methods. The Loblolly House, now located on Taylors Island in Maryland, was designed, fabricated, and assembled under the objectives of "[creating] a house that evokes the extraordinary natural world that is its home; then redesign the process of design and construction, embedding within it an environmental ethic that privileges efficiency and quality" (Kieran, 2008). Their motive was generated as a response to the rise of energy consumption within the economy which seems to have little regard for water or material conservation which tends to result in poorly structured spaces consisting of the underutilization of materials, leading to an increase of energy use as well as an increase of maintenance and cost. Kieran proceeded to directly criticize the current status of construction procedures by claiming that:

> Once synonymous with quality craftsmanship and symbolizing the highest levels of human achievement, our buildings are, more often than not, seen by the public as bastions of mediocrity. With each passing year, the litany of problems associated with incomplete, incorrect, or poor workmanship grows longer. In most cases, quality is applied after the fact, if at all. This method of operation is built into the existing process, with a "fix it later" work ethic and a "talk the owner and designer into accepting the compromises, because we are behind schedule and over budget" approach to problem solving (Kieran, 2008).

In order to propose a redirection of the profession, Kieran and Timberlake worked within the emendation of a sustainable and prefabricated approach that would ultimately "improve the productivity of design and construction, enhance affordability and quality, and do so in an ethical

and aesthetically moving manner" (Kieran, 2008). To achieve this non-optional mandate, the architects chose to return to the element of process in order to provide opportunities and guidance in their design, a method of which they claimed to have become obsolete, replaced by the mass production of form which produces construction drawings that describe, in minute detail, the puzzle, not the path. They also utilized BIM technology to its full potential as a means to minimize waste and expedite the construction process. Professor of architectural history at Colombia University, Barry Bergdoll emphasizes on the benefits of using BIM technology in consideration that "rather than distance the architect ever further from the actual making of things, digital tools have the possibility of creating a hand-to-glove relationship between design and fabrication, between the testing ground and the conditions of construction and natures of materials" (Bergdoll, 2008).

The digital modeling of Loblolly House was done in Revit and CadWorks, both of which were translated back and forth through AutoCAD. Once the parametric model was complete, "it became the tool for managing the supply chain" due to the fact that "much of the product information regarding structural properties, manufacturer product references, lead times, and dozens of other useful facts were readily present as annotated information in the parametric model" (Kieran, 2008). This method not only streamlined the supply chain but also made it so that the client was able to purchase everything directly. In addition to the structural properties and materials information embedded within the original design, the digital model assured that "dimensional certainty is a direct product of the parametric model" (Kieran, 2008). The accurate quantity survey resulted in the purchasing of only necessary materials which ultimately reduced the material waste (Kieran, 2008). In order to produce an efficient recovery and rebuild phase

within disaster relief efforts following the devastation of a hurricane, my final proposal will also utilize BIM technology within Revit so as to provide a process which minimizes material waste and expedites the completion time.

Once the digital model was complete and the materials were dimensioned and purchased in precision, Kieran and Timberlake reached out to a Philadelphia-based contractor from Arena Program Management to provide all on-site services while Tedd Benson and his New Hampshire-based company took charge of the off-site fabrication. In this arrangement, however, "the site no longer served as the factory, and nearly seventy percent of the effort shifted to off-site integration and fabrication" which allowed the individual components to simply be shipped to the site and literally inserted into the structure. This was made possible by Kieran and Timberlake's breaking down the Construction Specifications Institute's forty-eight divisions of a bewildering array of parts into fewer, highly individualized elements which included site, structure, floor-cartridge, block, and wall cartridge.

The site of Loblolly House consists strictly of the piles which raises the house from the ground and was the only form of construction that took place entirely on-site. Most of the piles were solid timber and placed either vertical or at an angle but "while timber piles [transferred] structural loads to the earth, two hollow piles [provided] open sleeves for supplying fresh water and power and for carrying wastewater" (Kieran, 2008). The structure of Loblolly House was comprised of aluminum scaffold which was cut to the precise length off-site and then transported to be easily assembled on-site. The use of the scaffold allowed for the floor and wall-cartridges as well as the blocks to simply be simply inserted into the aluminum structure rather than

constructed, so simple that “by day three of the assembly, the aluminum scaffold [was] ready to receive the blocks and cartridges” (Kieran, 2008). Kieran also goes on to explain that “through the agency of the scaffold, one can begin to imagine a new market based on relocation instead of demolition” (Kieran, 2008).

The floor and wall-cartridges are constructed entirely off-site and are readily equipped with all of their internal structure and utilities: the wall-cartridges are built with the doors and windows already in the units and the floor-cartridges come with the conduit elements for water, air, and electricity pre-installed. Kieran and Timberlake proceeded to thoroughly explain the uses of the cartridge shell in three basic functions:

> Within the house, the cartridge shell performs three basic functions. First, it handles live loads imposed by people, furnishings, and inclement weather, as well as dead structural loads from its own weight. The shell is composed of lumber ribs and plywood sheathing, and its loads are transferred to the scaffold. Second, the sheathing protects and contains the fragile and intelligent conduit elements for water, air, and electricity. Also, built-in electrical conduits power light fixtures and ceiling fans (Kieran, 2008).

The final element within Loblolly House is the block which includes ready-built bathrooms and mechanical rooms that like the cartridges, are entirely prefabricated off-site and later shipped so that can simply be inserted into the structure. Loblolly House consists of three system-intensive blocks: “first, a combined bathroom, closet, and mechanical room adjoins the master bedroom: second, the guest bathroom stacks above a half-level-high mechanical room: and third, a mechanical room and closet adjoin the kitchen” (Kieran, 2008). The use of these individualized elements in replacement of traditional construction techniques allowed for the house to be assembled rather than constructed and also at an incredibly fast rate. Kieran and Timberlake originally projected Loblolly House to be erected in two weeks but knew they were being far too

optimistic. They eventually settled on a three-to-four-week construction duration but in that assessment, they failed to take into consideration the site's unpredictable conditions. The house was finally complete after approximately six weeks (Figure 3).

Figure 3: Loblolly House Exterior (This image is licensed under a Creative Commons Attribution 3.0 Unported License for public use and redistribution.)

With the procedures shown through Kieran and Timberlake's denouncing of traditional construction techniques in order to develop an efficient and successful prefabricated module through the use of individualized elements, I intend to utilize this beacon of prefabricated architecture into my rebuild procedure for Staten Island following the destruction of Hurricane Sandy. With an iteration of this method, we could expedite the recovery phase considerably through the precision of BIM technology as well as cut down the amount of material waste considerably. In addition to the efficiency of this process, having the materials readily available, in preferably a prefabrication manufacturer, in areas highly prone to hurricane conditions would allow for an even faster approach to the reconstruction phase that has the potential of taking place immediately following the clean-up of the affected area. These methods in addition to

those previously mentioned will be utilized as iterations within my final proposition and physical model.

CHAPTER VII

ADDRESSING THE OPTIONS

The structure of my thesis is similar to the construction, or assembly, of a house. Each of my reviewed projects has been analyzed in accordance to their production: starting with the foundation and resulting in a water-tight livable space. In other words, I introduce the used method and material in the houses and infrastructures constructed for New Orleans and other prefabricated projects to determine their overall status and document the resulting factors as possible iterations for my own design. Such factors include the use of pier-and-beam or a concrete slab as a foundation or whether to construct on or off-site. Each of these possibilities are then documented in order to produce the most efficient process as well as an overall design that is financially readily available, structurally sounded, self-sustainable and aesthetically pleasing.

My proposal for the reconstruction phase within disaster relief efforts consists of two phases; immediate relief and permanent residency. The immediate relief focuses on the initial response directly following the natural disaster. So in addition to the people sent as first respondents on the scene, usually consisting of medical professionals and police officers, I propose that a crew designated to conduct the reconstruction phase of disaster relief to also respond to the initial call. This crew would then analyze the entire affected area and determine which infrastructures require immediate attention. The damaged buildings would then be documented and assorted in accordance to their demand: buildings with minor damage still housing the residents will be addressed first and the rest would follow suit. In my reviewed cases, however, residents were

evacuated from their homes so the immediate rebuild for the comfort of remaining civilians would prove irrelevant.

Even so, one of the main goals I wish to obtain is expedited return of all evacuated citizens to their homestead. Though it may not be the same living arrangements they had grown accustomed to over the years, my belief is that overall, your permanent location is still better than relocation. For it is from your permanent location that you are able to commute to work, interact with your friends and neighbors and receive the comfort of safety in your own space. Issues pertaining to relocation result in a change of demographics in the area as well as the demand for an immediate change in the victim's lives. In order to bottleneck these factors to a bare-minimum, one must expedite the process of reconstruction. With that said, the most significant notion mentioned in that particular case is time. So in the process of determining the best possible solution, one of the most prominent features in my reviewed project will be the construction duration.

Once the effected buildings have been thoroughly analyzed, the next step in the recovery phase will then be determined by the property owner before the rebuild phase breaks ground. Houses which suffered minor damage will more than likely choose to fix the abrasions rather than level the house and rebuild. However, not all disaster victims uphold that option. For the citizens that have to begin a new chapter in their lives, starting with the composition of a new homestead, I propose that a series of options be made readily available in order to assist them in their time of dire need. The possible selections would entail the procedures made in response to past disasters as well as the alternatives suggested by the works of my reviewed projects. The client would be presented with all available options for the reconstruction of their house, upholding the capability

to select the materials and construction/assembly techniques that best suit their desires, starting with the foundation and concluding with a new home.

FOUNDATION

When determining the available options for possible foundations of a home, one would be faced by three differing options: slab on grade, pier and beam or stilts. A slab on grade foundation is a structural engineering method which consists of the structure being connected directly to the ground by a concrete slab. This technique is most commonly used in areas that are not in threat of continuous freezing and thawing, eliminating the need for heat ducting or insulation beneath the floor. The materials used in a slab on grade foundation are wood, used to frame the footprint of the building, rebar, which acts as a skeleton to reinforce the concrete once poured, and of course, concrete. In addition to these materials, one would have to install plumbing rough-ins before pouring the slab. This is a common technique for the fact that it is fairly inexpensive and sturdy though being directly intact to the ground increases the possible risk of flooding. Considering that my project revolves around coastal projects damaged by flooding, this would prove to not be the best option, but all the while a prospect.

Another possible foundation structure would be the use of pier and beam construction. This method involves a disconnection from the earth and the home through minor elevation of the ground floor and results in a more secure footing than a concrete slab. The interstitial space is consumed by footings, piers and beams. The footings, which are made of reinforced masonry and used to anchor the pier and beam foundation, are buried beneath the maximum frost depth. The piers are then installed directly on the supporting footing. Pressure-treated wood is the most common material for piers but it can also be interchanged for steel. Once the piers are fixed in

place, beams are then laid and leveled atop of the piers. Once secured, they provide the frame for the floor boards that support the building's first level. Like the piers, the common material chosen when using beams is wood though it too can be interchanged for steel as well as aluminum. These alterations result in a reduction to the threat of termites and rotting wood. In this method, the floor would in fact be insulated in order to act as a barrier from exterior weather conditions. Along with the insulation, the house's plumbing and ductwork would also be located beneath the floor of the house, though with the available crawl space, one would be able to access the material if the need for repair were to ever arise. The pier and beam foundation is less susceptible to flooding than a slab on grade approach though in extreme weather conditions, water has been known to rise above the elevated ground floor and penetrate into the house.

The stilt foundation option allows the house to be elevated even further from the soil. Usually supported by large wooden pilings, the stilt foundation method suspends the house between 10 and 20 feet off the ground, depending on the flood plain of the region. The majority of the pilings are arranged to transfer the structural loads from the house to the earth below while a select few remain hollow. These casings provide protection for the plumbing utilities, directly attaching them to the base of the house. In this case, the pilings can also be interchanged with other materials. One such option is the use of reinforced concrete columns, commonly seen in parking garages and other industrial projects. Another possible material would be steel which would again minimize the risk of termites and possible rotting. Similar to the pier and beam foundation, the stilt method would require the insulation of the floor boards with the option of extra heating made available through ductwork. Out of the three foundation options, the stilt foundation provides the most protection from the threat of flooding. Even so, it still entails the disadvantage

of having to transfer vertically in order to access the livable space. Yet the space made available through the raising of the floor level provides an open area large enough for outside events as well as protective storage for vehicles.

FRAMING

Once the foundation has been established and applied to the property, the structural frame can then be laid out and assembled. Though each initial framing procedure varies between the mentioned foundations, the final results are all fairly similar. For instance, when starting the framing of a slab on grade house, a rat sill, or bottom plate, is anchored directly to the concrete. The wooden layout outlines the interior and exterior walls throughout the house, leaving space for the installment of doors and windows. The frame of the walls are then constructed and fastened to the rat sill. In most cases, the structural framing of a house consists mostly of wood. However, materials can, and have already been interchanged in order to allow for easier construction and less material waste. One such case is Kieran and Timberlake's Loblolly House. Based on a scaffold design, the frame of the house is made up entirely of aluminum. From this aluminum frame, they were able to assemble the house rather than construct it, reducing material waste and completion time. Floor, wall and ceiling cartridges were designed and prefabricated in order for eased installment into the frame. Grooves within the aluminum frame provided the simply connect the floors, walls and ceilings directly to the frame, resulting in an expedited completion time. Yet even though this option provides protection as well as punctuality, other possible solutions are also available.

ENCLOSURE

Once the house has been completely framed out, multiple methods can be implemented in order to protect the space from the outside environment. In traditional construction techniques, one would simply place wooden studs sixteen inches apart in order to frame the walls, enclose the space with particleboard, insert insulation and electric wiring and finish it up with some drywall. Marks are then laid out for the setting of the wooden, and in some cases prefabricated, roof trusses. From there, one would determine whether they want a gabled or a hipped roof and proceed to the concluding procedures in the construction process. However, as mentioned earlier, all of these tactics can be replaced with the use of off-site construction. Even so, all of these as well as other options will be made readily available for the client to choose from. But as previously implied, the client must not only decide the material but also the method.

ON-SITE CONSTRUCTION

The most common method applied to the erecting of a house is on-site construction. This profession dates back hundreds of years ago and requires the attainment of specific skills in order to master the art. Having evolved along with the time and technological advancements, the structural procedure still remains relatively the same; you start with the foundation and end with an enclosed space. However, the tools and methods used in the construction of the house have simultaneously advanced in accordance with the time. Yet even so, substantial waste and unmet deadlines still remain as common parasitic factors in this aging practice. The measure and cut as you go method provides a grey area between the contractor and the construction, leaving an area of uncertainty and eventually resulting in these shortcomings.

OFF-SITE CONSTRUCTION

A steadily growing profession, off-site construction has proved to not only minimalize construction waste but also decrease the overall completion time. Yet unlike on-site construction, this practice usually involves the integration of multiple professions. In order to provide the precise precut and preassembled materials, the architect has to work directly with the engineer, and the on-site contractor while concurrently maintaining a professional relationship with the client.

Off-site construction has evolved greatly since the arrival of BIM. Within the digital model of the house, the designer is able to not only determine the exact dimensions of the frame but is also capable of selecting the best materials for each element, including size and type. With this information, the structure is able to be prefabricated with precision and little to no waste. Also, with the materials accurately cut and assembled, the construction aspect is replaced with an assembly line. Instead of having to obtain the multitude of techniques and skills required to frame a house, one can simply read a set of instructions in order to assemble.

CHAPTER VIII

CONCLUSION

Upon presenting the homeowners suffering from the loss of their residence following the destruction of a hurricane with available options to consider when deciding how to rebuild not only their homes but their lives, I would also present my design as a consideration. Derived from my reviewed works, my proposal seeks to address the need of a ready-to-assemble product when necessary, such as following the destruction of homes after Hurricane Sandy. In order for my designs to be readily accessible following the disastrous effects of a hurricane, I suggest that the materials required for the individual components be made available from somewhere as specific as a prefabricated manufacturer or as simple as a department store. In other words, when needed, the affected area would have a kit-of-parts ready to respond to a call for reconstruction. If, by some means, the company would rather not load their stock with materials that may remain stagnant for an extended period of time, such as a surplus of pilings, the required materials for the rebuilding procedure can be shipped to the company when the area is most prone to undergo the destruction of a hurricane. Just as Le Corbusierand Fuller believed that houses were not only capable of being assembled in similar means as a car but that the process would also increase efficiency, having the materials readily available to be assembled into components when needed for the rebuilding of a home following a disaster would be just as efficient while at the same time increasing response time which would ultimately lead to a faster recovery and rehousing of displaced victims.

So as to make my design sustainable, I not only used energy efficient utilities and furnishings but also arranged my spaces with a minimum amount of corridors in order to maximize space while simultaneously providing the opportunity for the house to naturally ventilate by the use of operable windows, though in Staten Island, this would only be used in summer weather conditions. But unlike Billes Architects design for the MIR foundation, which embraced traditional methods in addition to energy efficient utilities, my design uses the least amount of traditional construction practices as possible. Instead, I chose to make my designs capable of being assembled through prefabricated procedures, similar to that of Loblolly House. This decision was made easy when considering that:

> Assembly is fast; construction takes much longer. Assembly can be performed with rudimentary skill and just a few simple tools. Construction, on the other hand, is complex and often requires considerable skill, training, and specialized tools and equipment. Assembly depends on factory-controlled cutting, prefitting, drilling, and jigging; it dictates field fabrication methods and fittings; and it can be completed with the aid of written instructions. For the most part, construction is directed by unwritten knowledge passed along through formal training and apprenticeship (Kieran, 2008).

Inspired by Kieran and Timberlake's Loblolly House, my design also utilizes the aluminum framing as a means of being capable of not only assembling the house but also being able to replace damaged individual components rather than the entire house if destroyed by a hurricane. However, in order to make my prototype more appealing to clients, I adopted Fuller's method of masking elements so as to not have the structure entirely exposed, unless preferred by the client.

Considering that my design is being proposed for the coastal community of Oakwood Beach Neighborhood on Kissam Avenue in Staten Island by means of preventing homes from being either destroyed or particularly flooded again by the devastating effects of a hurricane, I designed all my homes to be raised ten feet off the ground. I understand that this may come as an

inconvenience in means of visiting a neighbor or accessing a vehicle, since both would require the use of stairs, which is why I chose to design a raised public sidewalk that would allow for all homes to be connected on the same level. Since this accommodation only responds to the inconvenience of visiting a neighbor, I also propose the use of a parking garage; that is of course, if the community desires one. The garage would be located at the front of the community and would make it easier for residents to access the level of their homes by use of an elevator rather than stairs. This would also result in a maximization of green space beneath the homes as well as a minimization of vehicular traffic within the community (Figure 12).

In order to further simplify my design, I laid out my plans within twelve feet by twelve feet blocks. With this method, I was able to easily arrange and then rearrange the spaces in multiple different ways while maintaining a simple design and an easy dimension (Figure 4). And just as I was able to arrange these spaces with ease, the client would literally have a set of blocks to take, arrange, and rearrange until deciding upon their desired home layout. I chose the use of twelve foot blocks due to the fact that twelve can be broken down by two, three, four, and six feet, allowing for additional space to be easily acquired with only minor adjustments to the layout (Figures 5-10). The aluminum framing would mostly consist of a grid pattern and each wall, floor or ceiling component would be able to simply be inserted into the structure (Figure 11).

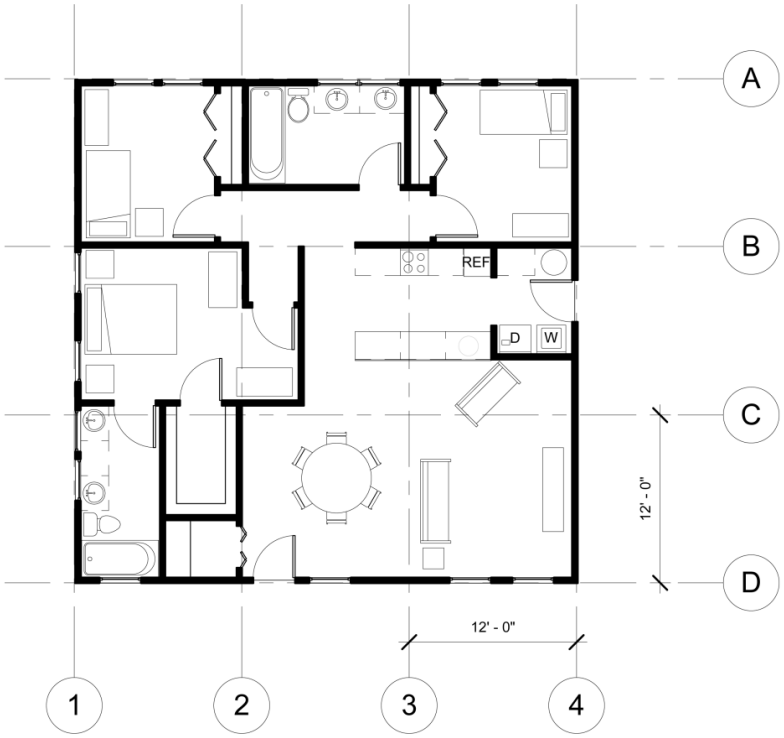

Figure 4: First Generation Floor plan

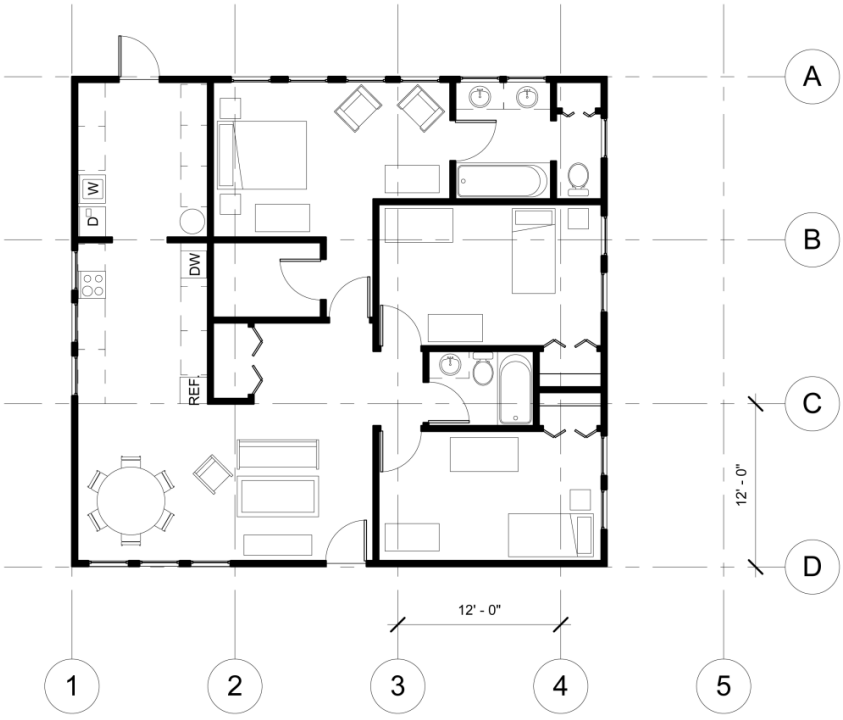

Figure 5: Second Generation Floor plan

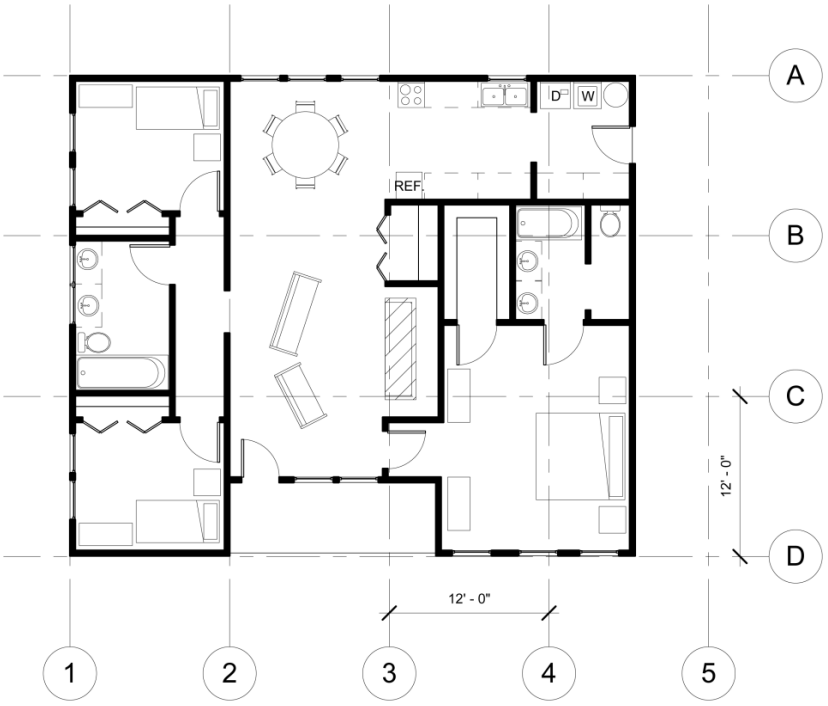

Figure 6: Third Generation Floor plan

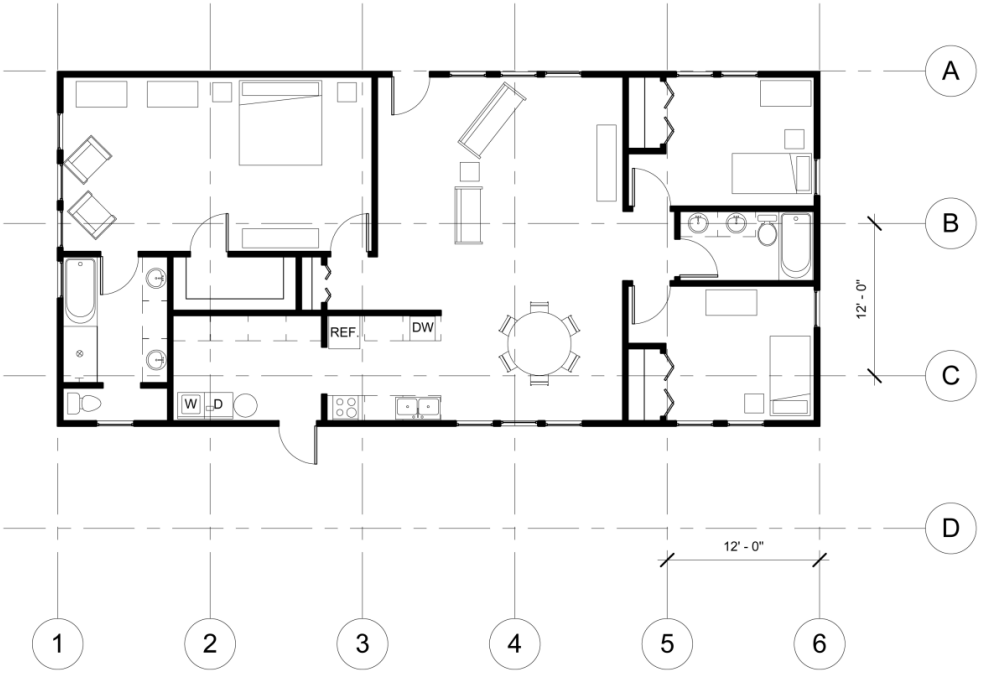

Figure 7: Fourth Generation Floor plan

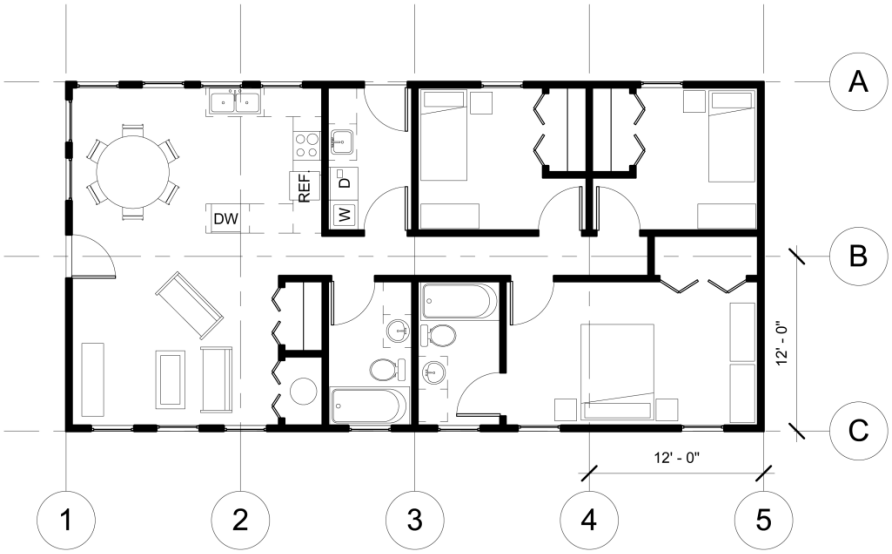

Figure 8: Fifth Generation Floor plan

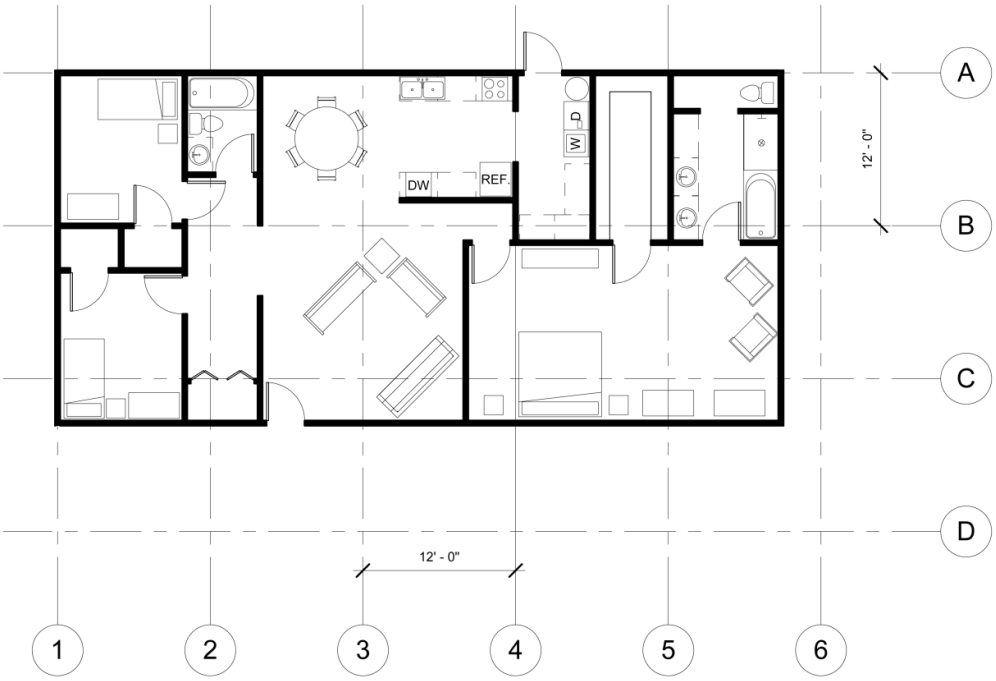

Figure 9: Sixth Generation Floor plan

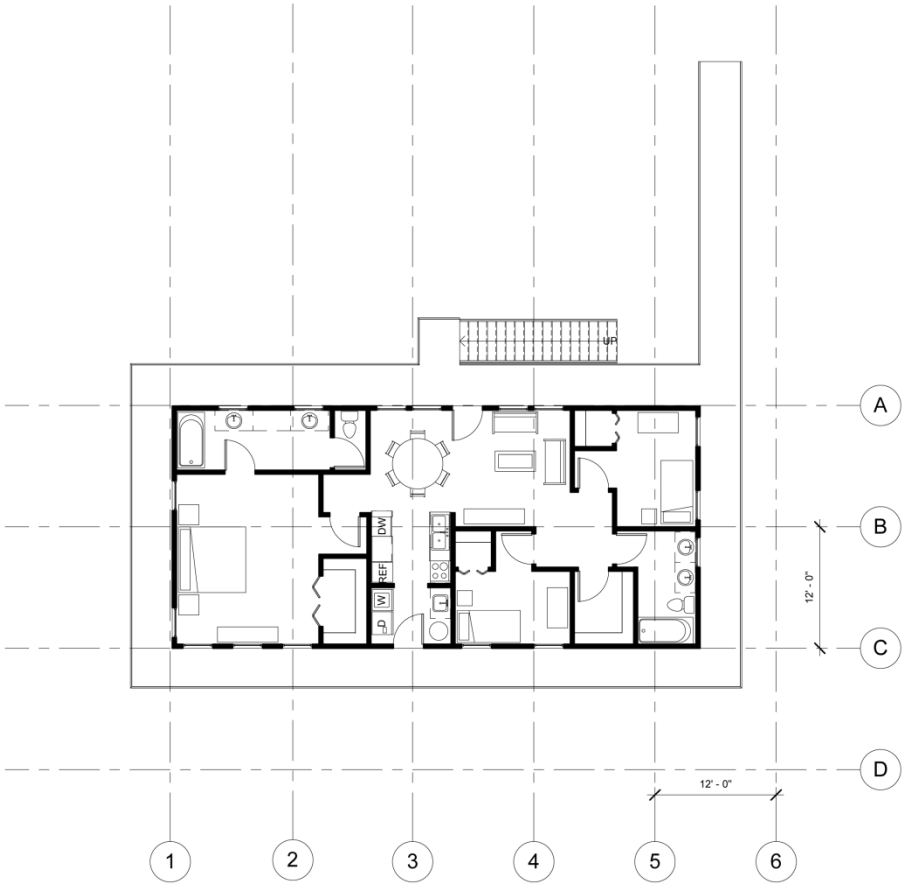

Figure 10: Seventh Generation Floor plan

Figure 11: Seventh Generation Interior

Figure 12: Seventh Generation Exterior

Though these layouts may be small, the technique of assembling the structures and arranging square to semi-square spaces provides the opportunity of expansion upon availability. As previously addressed, this method makes it simple to add as little as two feet here to as much as twenty-four feet there when deemed necessary by the client. My proposed methods as well as my model are again to be seen as a template or a standard. With the establishment of this standard, one is able to adjust the arrangement according to either the demand of the region or at the request of the client, and all can be done with ease. In terms disaster recovery, this model would be easy to install in an efficient manner by simply assembling the aluminum structure, prefabricating the wall, floor, ceiling an additional elements and inserting them on-site, all of which could take place immediately following the removal of debris which as stated previously results in less material waste, an expedited rebuild phase and the rehousing of displaced citizens following the devastation of a hurricane with the potential of adapting to all forms of disaster.

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